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Ron Turner
ANSER

Robert Cassanova
Director, NIAC Universities Space Research Association

The Next 50 Years: NIAC Leading the Way into the 21st Century

Dr. Ron Turner
ANSER
Suite 800
1215 Jefferson Davis Hwy
Arlington, VA 22202

Dr. Robert Cassanova, Director, NIAC
Universities Space Research Association
555-A 14th Street
Atlanta, GA 30318

Abstract

The National Aeronautics and Space Administration (NASA) Institute for Advanced Concepts (NIAC) was established in 1998 for the explicit purpose of being an independent source of revolutionary aeronautical and space concepts that could dramatically impact how NASA develops and conducts its mission. The institute is to provide a highly visible, recognized and high-level entry point for outside thinkers and researchers. The purpose of the NIAC is to provide an independent, open forum for the external analysis and definition of space and aeronautics advanced concepts to complement the advanced concepts activities conducted within the NASA Enterprises. The NIAC has advanced concepts as its sole focus. It addresses revolutionary concepts - specifically systems and architectures -that can have a major impact on missions of the NASA Enterprises in the time frame of 10 to 40 years in the future. It generates ideas for how the current NASA Agenda can be done better; it expands our vision of future possibilities. This paper describes NIAC, the projects undertaken to date, and opportunities for the future.

Imagine

A magnetized plasma bubble is riding the solar wind, delivering payloads to the outer planets in months instead of years. Swarms of thousands of thumb-nail sized "mesocopters" are measuring the outgasing of an awakening volcano on Titan. A long-duration, nuclear ramjet-powered unmanned aircraft is navigating the winds of Jupiter. A colony of robotic swimmers are exploring remote oceanic vents under the Europan ice.

Meanwhile, in the inner planets, cycling Astro-tels transfer passengers to Mars and back. Many of them had prepared for the journey at a self-sustaining colony at the lunar south pole. Their supplies had been delivered to the Moon sling-shot-style, by Earth-orbiting rotating tethers. New equipment they will be using at Mars is cruising along a separate trajectory, tossed by a similar network of tethers.

Back on Earth, teams of astronomers are looking at recent data on planets circling near-by stars taken from advanced high-resolution telescopes observing in the visible and x-ray spectra. They are working with collaborators who hope to send the first probes toward these planets. Down the hall, colleagues in the Earth Sciences are putting together a decade-long climate forecast after assimilating data collected in part from a global network of high-altitude, long duration balloons.

This vision is derived from a sampling of the many studies in aerospace and aeronautics underway or completed through the auspices of the NASA Institute for Advanced Concepts (NIAC).

What is NIAC?

The Universities Space Research Association (USRA) has established the National Aeronautics and Space Administration (NASA) Institute for Advanced Concepts (NIAC) under contract from NASA headquarters through the Goddard Space Flight Center. The NIAC was created to be an independent source of revolutionary aeronautical and space concepts that could dramatically impact how NASA develops and conducts its mission. It provides a highly visible, recognizable, and high-level entry point for outside thinkers and researchers. Toward this end, NIAC study funds are not available to NASA Centers.

The NIAC provides an open forum for the external analysis and definition of space and aeronautics advanced concepts to complement the advanced concepts activities conducted throughout NASA's enterprises. It focuses on revolutionary concepts systems and architectures that can have a major impact on NASA missions in 10 to 40 years. The emphasis on systems and architectures is critical and bears further elaboration (Figure 1). NIAC is not a source of funding for technology enablers: devices, subsystems, components, design techniques, analyses, and modeling generally associated with engineering and scientific disciplines. Such studies are appropriately the domain of NASA future technology and mission-specific programs.

The NIAC seeks proposals for advanced concepts that are appropriate for NASA missions. The NASA Strategic Plan [1] and NASA enterprise strategic plans [2] provide valuable background information about the visions of future aeronautics and space programs and should be a starting point for the development of revolutionary concepts being sought by NIAC. Proposers should be familiar with the information supplied in the NASA website (http://www.nasa.gov/), which provide valuable insight into the NASA mission, current activities, and future direction. The emphases of the NASA enterprises are shown in Table 1.

While the scope of the NIAC is based on the NASA planning documents and future mission plans of the NASA enterprises, it is intended to generate new ideas for improving NASA's current agenda and to expand NASA's future possibilities. NIAC concepts are bounded only by the horizons of human imagination.

Figure 1: NIAC Mission

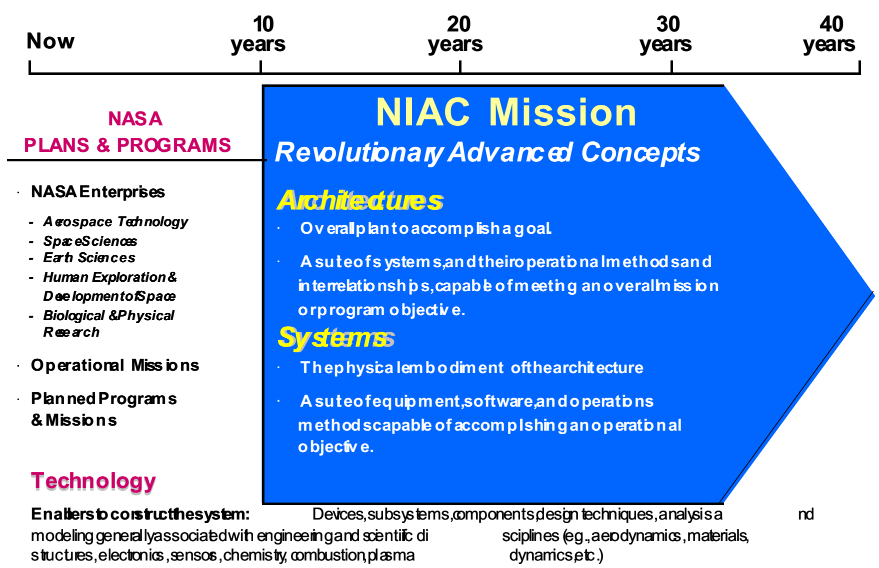

Table 1: NASA Enterprises

Aerospace Technology	pioneers the identification, development, verification, transfer, application and commercialization of high-payoff aeronautics and space transportation technologies.
Earth Science	uses the unique vantage point of space to provide information about Earth's environment that is obtainable in no other way. In concert with research and industry partners, the Enterprise is developing the understanding needed to support the complex environmental policy and economic investment decisions that lie ahead.
Human Exploration and Development of Space	opens the space frontier by exploring, using and enabling the development of space and to expand the human experience into the far reaches of space.
Space Science	examines the mysteries of the universe, explore the solar system, discovers planets around other stars, searches for life beyond Earth from origins to destiny, charts the evolution of the universe to understand its galaxies, stars, planets, and life.
Biological and Physical Research	conducts basic and applied research to support human exploration of space and to take advantage of the space environment as a laboratory: how can human existence expand beyond the home planet to achieve maximum benefits from space? how do fundamental laws of nature shape the evolution of life?

How is NIAC Organized?

The NIAC organizational structure is shown in figure 2. The institute's director and staff are located in Atlanta, Georgia. It gets administrative support and corporate guidance from the USRA headquarters in Columbia, Maryland. ANSER, a not-for-profit public service research institute based in Arlington, Virginia, provides information technology support and technical assistance.

The NIAC activities are reviewed semi-annually by the NIAC Science and Engineering Council, a board of distinguished members representing a wide variety of aerospace expertise. Members of the board are listed in table two.

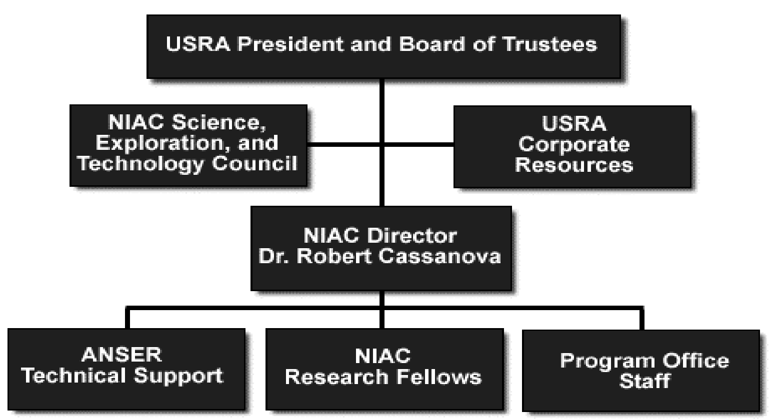

Figure 2: NIAC organizational structure

Membership of the NIAC Science, Exploration and Technology Council	
Dr. Mark R. Abbott Oregon State University	Dr. Jerry Grey Consultant
Dr. Peter M. Banks University of Michigan	Dr. Wes Huntress Carnegie Institute of Washington
Dr. David Black USRA	Gentry Lee Consultant
Dr. George L. Donohue George Mason University	Dr. Lynn Margulis University of Massachusetts - Amherst
Dr. Burt Edelson USRA	Dr. Taylor Wang Vanderbilt University
Dr. John V. Evans COMSAT Corporation	Dr. Robert Whitehead Consultant

Table 2: NIAC Science and Engineering Council

How does NIAC work?

The normal development of NIAC advanced concept studies is carried out through issuance of research grants or subcontracts in a two-phased approach modeled after the U.S. Government's Small Business Innovative Research Programs. Phase I awards of approximately $50,000 to $75,000 will be granted for six months to validate the viability of the proposed concept and define major feasibility issues. Phase II awards of $350,000 to $500,000 will be granted for 18 to 24 months to study the major feasibility issues associated with cost, performance development time, and key technology issues.

Both Phase I and Phase II awards are competitively selected by the NIAC, based on an independent peer review. The process begins with a Phase I announcement of opportunity, released through the Commerce Business Daily, posted on the NIAC web page (www.niac.usra.edu), and distributed to the NIAC mailing list. The community generally has two to three months to respond with a 12-page proposal. For example, the most recent Phase I call was released on September 22 2000, with a due date of February 18, 2001. All proposals are submitted electronically in a standard Adobe PDF format (details are provided in the preparation instructions [3]). After receiving the proposals, NIAC distributes them for peer review. Based on the results of this peer review, NIAC submits a list of tentative awards to NASA headquarters for concurrence. Approved awards to the newly designated NIAC Fellows are generally on contract within weeks of the Concurrence Briefing. At the end of the six-month Phase I study, Fellows submit their final reports, which are posted on the NIAC web page. Fellows may also at this time submit a proposal for Phase II funding. The process of down-selecting to Phase II is similar to the selection process for Phase I.

During the course of the Phase II studies, the Fellows generally are responsible for one or more site visits and for a final report. NIAC works with the Fellows and with appropriate NASA Centers during this period to help identify sources of future NASA funding for successful concepts.

What has NIAC done so far?

In its first three years of operation (February 1998 to February 2001) NIAC has received 338 proposals and issued 62 awards, including 46 Phase I studies and 16 Phase II studies. The proposals have come from across the business spectrum, from small businesses, large businesses, universities, and even national laboratories as shown in figure 3.

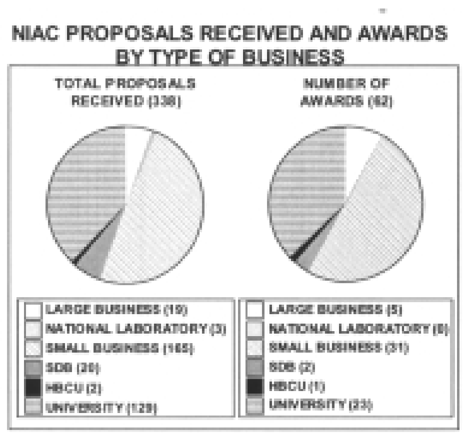

Figure 3: NIAC Proposals and Awards by business category. (SBD Small Disadvantaged Business; HBCU Historically Black Colleges and Universities)

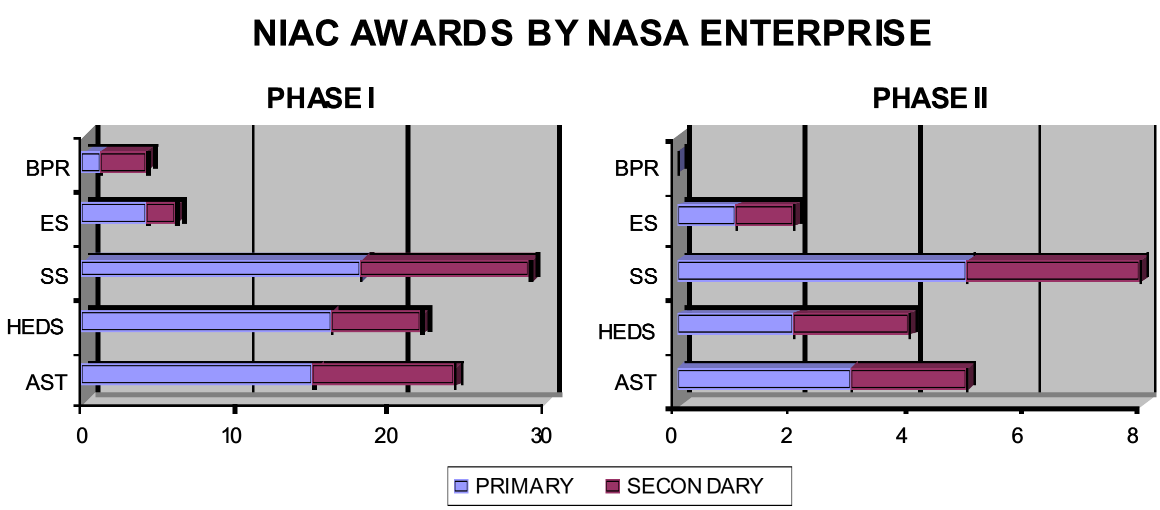

Figure 4: NIAC Awards by NASA Enterprise. BPR—Biological and Physical Research; ES—Earth Science; SS Space Science; HEDS Human Exploration and Development of Space AST Aerospace Technology

Area	Principal Investigator	Phase	Investigation Title
Space Transportation	Bogar, Thomas J	I	Hypersonic Airplane Space Tether Orbital Launch System
	Grant, John	II	Hypersonic Airplane Space Tether Orbital Launch (HASTOL) Study - Phase II
	Spieth, Dean	I	Ultralight Solar Sails for Interstellar Travel
	Edwards, Bradley	I, II	The Space Elevator
	Hawk, Clark W	I	Plasma Pulsed Power Generator
	Howe, Steven D	I	Enabling Exploration of Deep Space: High Density Storage of Antimatter
	Hoyt, Robert P	I, II	Tether Transport System for LEO-MEO-GEO-Lunar Traffic
	Kammash, Terry	I	Antiproton-Driven, Magnetically Insulated Inertial Fusion (MICF)
	Landis, Geoffrey A	I	Advanced Solar and Laser Pushed Lightsail Concepts
	LaPointe, Michael R	I	Primary Propulsion for Piloted Deep Space Exploration
	Maise, George	I, II	Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer
	McNutt, Ralph L	I, II	A Realistic Interstellar Explorer
	Nock, Kerry T	I, II	Cyclical Visits to Mars via Astronaut Hotels
	Seward, Clint C	I	Low Cost Space Transportation Using Electron Spiral Toroid (EST) Propulsion
	Slough, John	I	Rapid Manned Mars Mission With a Propagating Magnetic Wave Plasma Accelerator
	Winglee, Robert M	I, II	Mini-Magnetospheric Plasma Propulsion
	Zubrin, Robert	I	The Magnetic Sail
Aeronautics	Colozza, Anthony	I, II	Planetary Exploration Using Biomimetics
	Hoskins, Paul D	I	An Advanced Counter-Rotating Disk Wing Aircraft Concept
	Stancil, Charles M	I	Electric Toroid Rotor Technology Development
	Tyll, Jason	I	Environmentally-Neutral Aircraft Propulsion Using Low-Temperature Plasmas
	Van Buiten, Chris	I	Autonomous VTOL Scalable Logistics Architecture
	Keith,Andrew	II	Methodology For The Study Of Autonomous VTOL Scalable Logistics Architecture
	Kroo, Ilan	I, II	Meso-Scale Flight Vehicle for Atmospheric Sensing
Astronomy	Bekey, Ivan.	I	Assessment of the Feasibility of Extremely Large, Structureless Optical Telescopes and Arrays
	Gold, Robert E	I	SHIELD: A Comprehensive Earth Protection System
	Cash, Webster	I, II	X-ray Interferometry
	Gorenstein, Paul	I, II	Ultra high Throughput X-Ray Observatory With a New Mission Architecture
	Howard, Timothy L	I	Planetary-Scale Astronomical Bench
	Palisoc, Arthur L	I	Large Telescope Using Holographically Corrected Membranes
	Woolf, Neville J	I, II	Very Large Optics for the Study of Extrasolar Terrestrial Planets
Planetary Colonization	England, Christopher	I	Mars Atmosphere Resource Recovery System (MARRS)
	Rice, Eric E	I	Development of Lunar Ice Recovery System Architecture
	Rice, Eric E	I, II	Advanced System Concept for Total ISRU-Based Propulsion & Power Systems for Unmanned and Manned Mars Exploration
	Boston, Penelope J	I	Scientific Exploration and Human Utilization of Subsurface Extraterrestrial Environments
	O'Handley, Douglas	I	System Architecture Development for a Self-Sustaining Lunar Colony
	Powell, James	I	Development of Self-Sustaining Mars Colonies Utilizing the North Polar Cap and the Martian Atmosphere
	Ignatiev, Alex	I	New Architecture for Space Solar Power Systems: Fabrication of Silicon Solar Cells Using In-Situ Resources
	Brown, Christopher	I	Programmable Plants: Development of an In Planta System for the Remote Monitoring and Control of Plant Function for Life Support
Robotics	Dubowsky, Steven	I, II	Self-Transforming Robotic Planetary Explorers
	Farritor, Shane	I	A Modular Robotic System to Support the Surface Operations of Human Mars Exploration
	Jacobs, Ron	I	Biologically Inspired Robot for Space Operations
	Molnar, Peter	I	Self-Organized Navigation Control for Manned and Unmanned Vehicles in Space Colonies
	Vaneck, Thomas W	I	A System of Mesoscale Biomimetic Roboswimmers for Exploration and Search of Life on Europa
Advanced Systems	Nock, Kerry	I, II	Global Constellation of Stratospheric Scientific Platforms
	Campbell, Mark E	I	Intelligent Satellite Teams for Space Systems
	LaForge, Larry E	I	Architectures and Algorithms for Self-Healing Autonomous Spacecraft
	Maclay, Jordan	I	Feasibility of Communications Using Quantum Correlations

Figure 5: NIAC awards by Principal Investigator, phase, and investigation title

To ensure that NIAC reaches out to potentially untapped resources, NASA centers are not permitted to bid on NIAC awards. However, it is the intent of the institute to reach across NASA enterprises. Figure 4 shows NIAC awards by NASA Enterprise. In the figure, a study is primary if it directly relates to an enterprise, and secondary if it could contribute to the enterprise mission. Through February 2001 the awards under-represent the NASA Biological and Physical Research and Earth Science Enterprises. An active effort is underway to more effectively tap the communities that can contribute to these enterprises.

A complete list of awards through February 2001 is provided in Figure 5. Note this list does not include Phase I awards from those proposals due in February 2001.

In addition to the selection, funding, and review of advanced concepts, NIAC supports a range of activities designed to reach out to the widest possible audience. Among these activities are development and maintenance of a NIAC web site, hosting annual meetings and workshops, and participation in NASA-sponsored conferences and workshops.

The web site is used to make NIAC activities available to the aerospace community. It contains an overview of the institute, information about recent and pending activities, details about open and previous calls for proposals, and summaries and final reports for all funded studies, often with links to relevant work at NASA and in the aerospace community.

NIAC s annual meetings are opportunities for the Fellows to present the status of on-going work and to interact with other Fellows and with NASA. NIAC also periodically conducts focused workshops. The most recent of these was held November 7-8, 2000, in Atlanta, Georgia. It brought together representatives of diverse communities to discuss innovation at the interface of disciplines. One of NIAC s first activities was a workshop on NASA Grand Challenges in May, 1998. It helped establish the vision toward which NIAC aspires. The results of these workshops and announcements of upcoming meetings and workshops are posted on the NIAC home page.

What is ahead?

The next call for Phase I proposals is planned for release in the Fall of 2001. If you have an idea for an advanced concept and you want to get on the NIAC mailing list for the next announcement of opportunity, or if you just want to learn more about the NIAC, visit the NIAC web site at www.niac.usra.edu.

References

1. NASA 2000 Strategic Plan: www.hq.nasa.gov/office/codez/plans.html
2. NASA Enterprise Strategic Plans:
   a. Human Exploration and Development of Space: www.hq.nasa.gov/osf/heds/hedsplan.html
   b. Earth Science http: www.earth.nasa.gov/visions/stratplan/index.html
   c. Space Science: spacescience.nasa.gov/strategy/1997/
   d. Biological and Physical Research: www.hq.nasa.gov/office/olmsa/
   e. AeroSpace Technology: www.aerospace.nasa.gov/
3. NIAC Calls for Proposal: www.niac.usra.edu